UNITED STATES PATENT AND TRADEMARK OFFICE

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/823,364	04/12/2004	Steven C. Shannon	8756/ETCH/DICP	4844

55649   7590   04/22/2010
MOSER IP LAW GROUP / APPLIED MATERIALS, INC.
1030 BROAD STREET
2ND FLOOR
SHREWSBURY, NJ 07702

EXAMINER
ANGADI, MAKI A

ART UNIT	PAPER NUMBER
1713	

NOTIFICATION DATE	DELIVERY MODE
04/22/2010	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

ATABOADA@MOSERIPLAW.COM
DOCKETING@MOSERIPLAW.COM

UNITED STATES PATENT AND TRADEMARK OFFICE

_____

BEFORE THE BOARD OF PATENT APPEALS
AND INTERFERENCES

_____

Ex parte STEVEN C. SHANNON, DENNIS S. GRIMARD,
THEODOROS PANAGOPOULOS, DANIEL J. HOFFMAN,
MICHAEL G. CHAFIN, TROY S. DETRICK, ALEXANDER
PATERSON, JINGBAO LIU, TAEHO SHIN, and
BRYAN Y. PU

_____

Appeal 2009-009785
Application 10/823,364
Technology Center 1700

_____

Decided: April 20, 2010

_____

Before CHUNG K. PAK, CHARLES F. WARREN, and
TERRY J. OWENS, *Administrative Patent Judges*.

OWENS, *Administrative Patent Judge*.

DECISION ON APPEAL

STATEMENT OF THE CASE

The Appellants appeal under 35 U.S.C. § 134(a) from the Examiner's

rejection of claims 1-14 and 33-46, which are all of the pending claims. We

have jurisdiction under 35 U.S.C. § 6(b).

The Invention

The Appellants claim a method for using a dual frequency radio frequency (RF) source to control plasma characteristics in a semiconductor substrate etch processing chamber. Claim 1 is illustrative:

1. A method of controlling characteristics of a plasma in a semiconductor substrate etch processing chamber using a dual frequency RF source, comprising:

supplying a first RF signal to a first electrode disposed in an etch chamber; and

supplying a second RF signal to the first electrode, wherein an interaction between the first and second RF signals is used to control at least one characteristic of a plasma formed in the etch chamber.

The References

| Demaray | 2003/0127319 A1 | Jul. 10, 2003 |
| Dhindsa | 2003/0148611 A1 | Aug. 7, 2003 |

M.A. Lieberman et al., "Standing wave and skin effects in large-area, high-frequency capacitive discharges", 11 *Plasma Sources Sci. Tech,* 283-93 (2002) (hereafter Lieberman).

V. Georgieva et al., "Numerical study of Ar/CF$_4$/N$_2$ discharges in single- and dual-frequency capacitively coupled plasma reactors", 94 *J. Appl. Phys.,* 3748-56 (Sep. 15, 2003) (hereafter Georgieva).

The Rejections

The claims stand rejected under 35 U.S.C. § 103 as follows: claims 1-3 and 10 over Demaray; claims 40-42 over Demaray in view of Dhindsa; claims 4-9, 11 and 12 over Demaray in view of Georgieva; claims 13 and 33 over Demaray in view of Georgieva and Lieberman; claim 14 over Demaray in view of Georgieva and Dhindsa; claims 34, 35, 37-39 and 43-46 over

Dhindsa in view of Lieberman and Demaray;[1] and claim 36 over Dhindsa in view of Lieberman, Demaray and Georgieva.

<div align="center">OPINION</div>

The rejections are affirmed as to claims 1-12, 33-37 and 39, and reversed as to claims 13, 38 and 40-46.

<div align="center">*Rejections of claims 1-12, 14, 33-37 and 39*</div>

Issue

Have the Appellants indicated reversible error in the Examiner's determination that the applied prior art would have rendered prima facie obvious, to one of ordinary skill in the art, supplying first and second RF signals to the same electrode in an etch chamber such that an interaction between the signals controls at least one characteristic of a plasma in the etch chamber?

Findings of Fact

Demaray discloses a bias sputtering process which simultaneously deposits and etches a film (¶ 0048). The sputtering process can be a dual frequency RF sputtering process in which both high frequency RF power, typically 13.56 MHz, and low frequency power, typically about 100-400 kHz, are applied to a sputtering target which acts as a cathode (¶¶ 0011, 0024, 0043). Typically the high frequency RF power is about 500-5000 watts and the low frequency RF power is about 500-2500 watts, with the low frequency RF power being about 1/10 to about 3/4 of the high

---

[1] The Examiner omits Demaray from the statement of the rejection, but includes Demaray in the discussion of the rejection (Ans. 12), and in the Reply Brief the Appellants presume that this rejection is over Dhindsa, Lieberman and Demaray (Reply Br. 11-12). Hence, we include Demaray in this rejection.

frequency RF power (¶ 0043). The high frequency RF power is chiefly responsible for sputtering the target material and the low frequency RF power causes plasma ions to bombard the film being deposited on a substrate, resulting in sputtering and densification of the film. *See id.* Substrate bias is provided by RF power applied to the substrate (¶ 0046). The substrate bias RF power can be similar to the 13.56 MHz high frequency power or can be in the low frequency RF range. *See id.* "When power is applied to the substrate, a so-called plasma sheath is formed" (¶ 0047). "The effects of adding substrate bias are akin to, but more dramatic than, the effects of adding the low frequency RF component to the sputter source." *See id.*

Dhindsa discloses a plasma etching process wherein dual RF frequencies, for example 2 MHz and 27 MHz, are simultaneously applied to a substrate holder (chuck 202, 302) during etching (¶¶ 0023, 0029).

Georgieva discloses RF plasma etching simulations which compare single (13.56 MHz) and dual (2 + 27 MHz) frequencies (abstract).

Liebermann discloses mathematical model results which show plasma electric field directions and contours as a function of plasma sheath edge and radial edge at frequencies of 13.56 MHz and 40.7 MHz (Figs. 8 and 10).

Analysis

The Appellants argue with respect to claim 1 that Demaray merely discloses (¶ 0043) RF signals applied to the target to provide independent control of different plasma characteristics and that Demaray is silent as to any interaction between the RF signals (Br. 4-6; Reply Br. 5-6). The Appellants argue that Demaray does not teach or suggest either an effect on

the plasma caused by an interaction between the two RF signals or control of that effect via control over the interaction (Br. 6-7).

The Appellants' RF frequencies also provide independent control of different plasma characteristics. "For example, high frequencies effect ionization and dissociation, while lower frequencies effect sheath modulation" (Spec. ¶ 0039). As indicated by the Appellants' Figure 3 the interaction is an inherent result of the RF high and low frequencies being applied to the same electrode. Because Demaray's RF high and low frequencies also are applied to the same electrode (¶ 0043), it appears that like the Appellants' high and low frequencies, they necessarily interact. Hence, the burden has shifted to the Appellants to show that there is no interaction, and the Appellants have not carried that burden. *See In re Best*, 562 F.2d 1252, 1255 (CCPA 1977):

> Where, as here, the claimed and prior art products are identical or substantially identical, or are produced by identical or substantially identical processes, the PTO can require an applicant to prove that the prior art products do not necessarily or inherently possess the characteristics of his claimed product. [citation omitted] Whether the rejection is based on "inherency" under 35 USC 102, on "prima facie obviousness" under 35 USC 103, jointly or alternatively, the burden of proof is the same, and its fairness is evidenced by the PTO's inability to manufacture products or to obtain and compare prior art products.

As for the Appellants' argument that Demaray does not disclose control of an effect on a plasma by control over the interaction (Br. 7), the Appellants exert control over the interaction by controlling the ratio between the high and low frequency RF power sources; as stated in the Appellants' Specification, "[a]djusting the ratio between the source 122 and 123 controls the characteristics of the plasma" (Spec. ¶ 0019). Demaray likewise adjusts

the ratio of the high frequency and low frequency RF power (¶ 0043, "the low frequency power is from about a tenth to about three quarters of the high frequency power"). Hence, it appears that like the Appellants, Demaray controls plasma characteristics via an interaction between the high and low frequency RF signals. The Appellants, therefore, have the burden of providing evidence to the contrary, and the Appellants have not carried that burden. *See Best*, 562 F.2d at 1255.

Regarding claim 2 which requires that "the plasma characteristic is at least sheath modulation" the Appellants argue that Demaray discloses that a separate bias signal is used to create a plasma sheath about the substrate (¶ 0047), and that Demaray does not teach or suggest using an interaction between two RF signals to control plasma sheath modulation (Br. 8; Reply Br. 6-7).

Demaray discloses that substrate bias power can be either at the 13.56 MHz high frequency or in the range of the low frequency RF, and that "[w]hen power is applied to the substrate, a so-called plasma sheath is formed" (¶¶ 0046-47). That disclosure combined with Demaray's disclosure that "[t]he effects of adding substrate bias are akin to, but more dramatic than, the effects of adding the low frequency RF component to the sputter source" (¶ 0047) indicates that the low frequency RF power applied to the sputter source (¶ 0043) contributes to the formation of a plasma sheath. The Appellants disclose that "RF sources 122, 123 provide bias power that both self-biases the substrate and modulates the plasma sheath" (Spec. ¶ 0019). The Appellants disclose that "RF sources 122[low frequency source], 123 [high frequency source] provide up to about 10,000 Watts of total RF power in a predetermined power ratio from the source 122 to the source 123

between 1:0 and 0:1." *See id.* Similarly, Demaray's low frequency and high frequency power sources provide up to 7,500 Watts at a low frequency to high frequency ratio between about 0.1 and about 0.75. *See id.* Thus, it appears that like the Appellants' high frequency and low frequency RF power sources, Demaray's low frequency and high frequency RF power sources modulate a plasma sheath. Consequently, the burden has shifted to the Appellants to provide evidence to the contrary, and the Appellants have not carried that burden. *See Best*, 562 F.2d at 1255.

The Appellants argue that Demaray fails to teach or suggest the claim 10 requirement that "the plasma characteristic is at least a power distribution within the plasma" (Br. 8-9; Reply Br. 7-8).

The Appellants disclose that their RF power sources 122 and 123 provide up to about 10,000 Watts of total RF power and that adjusting the ratio between sources 122 and 123 controls the characteristics of the plasma (Spec. ¶ 0019). Demaray' low frequency and high frequency power sources provide, respectively, about 500 to 2,500 Watts and about 500 to 5,000 Watts, and the low frequency to high frequency power ratio is adjusted between about 0.1 and about 0.75 (¶ 0043). Therefore, it appears that like the Appellants' adjustment of their low frequency to high frequency RF power source ratio, Demaray's adjustment of the low frequency to high frequency RF power source ratio provides an interaction which controls power distribution within the plasma. Thus, the burden has shifted to the Appellants to provide evidence to the contrary, and the Appellants have not carried that burden. *See Best*, 562 F.2d at 1255.

Regarding claim 4 which requires that "the first RF signal provides a broad ion energy distribution and the second RF signal provides a peaked,

well defined ion energy distribution" the Appellants argue that Georgieva fails to teach or suggest that an interaction between frequencies can be used to control plasma properties (Br. 10-11; Reply Br. 9).

As discussed above, Demaray's low and high frequencies appear to have such an interaction. The Appellants' Figure 3 indicates that the broad and peaked ion energy distributions required by claim 4 are an inherent result of low and high frequency RF being applied to the same electrode. One such electrode is the backing plate (25) of Demaray's sputtering target (Fig. 1a).

With respect to claim 9 which requires "supplying a third RF signal to a second electrode to form the plasma" the Appellants argue that Demaray does not teach or suggest that claim requirement (Br. 12).

Demaray's disclosures that the bias power to the substrate can be similar to the high frequency RF power applied to the sputtering target and that the high frequency RF power applied to the sputtering target is chiefly responsible for sputtering material off the target (via the plasma which is formed) (¶¶ 0043, 0046) indicate that like the high frequency RF power applied to the sputtering target, the high frequency RF power applied to the substrate contributes to the formation of the plasma.

Regarding claim 11 which requires that "the first and second RF signals provide similar plasma excitation properties and different spatial uniformity profiles" the Appellants argue that Georgieva's Figures 2 and 3 fail to teach or suggest a modification of Demaray that would result in spatial distributions that vary as a function of frequency (Br. 12).

Because, like the Appellants (Spec. ¶ 0019), Demaray uses low and high RF frequencies (¶ 0043), it appears that like the Appellants' low and

high RF frequencies Demaray's low and high frequencies provide different spatial uniformity profiles.

The Appellants argue regarding claim 12 which requires that "the interaction between the first and second RF signals is a varying effect on the power distribution in the plasma", that Georgieva fails to teach or suggest a modification to Demaray that results in that claim requirement (Br. 13).

Because, like the Appellants (Spec. ¶ 0019), Demaray can vary the ratio of low frequency RF power to high frequency RF power (¶ 0043), it appears that like the Appellants' interaction Demaray's interaction between the low and high frequency RF signals discussed above can have a varying effect on the power distribution in the plasma.

Regarding claim 14 which requires that "the interaction between the first and second RF signals is used to control the uniformity of a plasma enhanced etch process" the Appellants argue that Demaray discloses a different method (¶¶ 0029-30) for controlling uniformity (Br. 16-17).

The Appellants' claim 14 does not require that only the interaction between the first and second RF signals is used to control the plasma uniformity. Demaray's disclosure that the application of the RF power to the target periphery is uniform (¶ 0040) indicates that Demaray's application of low frequency and high frequency RF power and their apparent inherent interaction as discussed above contribute to plasma uniformity.

With respect to claim 33 which requires that "the first RF signal has a frequency of about 2 MHz and the second RF signal has a frequency of about 13.56 MHz" the Appellants argue that none of the references teach or suggest that frequency is a result effective variable (Br. 15).

Demaray's teaching that the RF power low frequency of about 100 to 400 kHz is typical (¶ 0043) would have led one of ordinary skill in the art, through no more than ordinary creativity, to use other low frequencies which are known in the art in dual frequency devices for forming plasmas, such as the 2 MHz disclosed by Georgieva (abstract). *See KSR Int'l. Co. v. Teleflex Inc.*, 550 U.S. 398, 418 (2007) (In making an obviousness determination one "can take account of the inferences and creative steps that a person of ordinary skill in the art would employ").

The Appellants' arguments concerning claims 34, 36 and 37 are similar to those set forth with respect to claims 1, 10 and 33 (Br. 17-19), and are not persuasive for the reasons given above regarding those claims.

Conclusion of Law

The Appellants have not indicated reversible error in the Examiner's determination that the applied prior art would have rendered prima facie obvious, to one of ordinary skill in the art, supplying first and second RF signals to the same electrode in an etch chamber such that an interaction between the signals controls at least one characteristic of a plasma in the etch chamber.

Rejections of claims 13, 38 and 40-46

Issue

Have the Appellants indicated reversible error in the Examiner's determination that the applied prior art would have rendered prima facie obvious, to one of ordinary skill in the art, 1) a combined effect of first and second RF signals that produces a substantially flat power distribution (claims 13 and 38), or 2) positioning beneath a substrate support surface an electrode to which first and second RF signals are applied (claims 40-46).

Analysis

Regarding claims 13 and 38 the Examiner argues that "Lieberman teaches how spatial power distribution (page 287) depends on frequency" (Ans. 9) and that "Lieberman teaches radial plasma electric field distribution for different frequencies (see Figs. 8 and 10)" (Ans. 16). The Examiner argues that "[o]ne of ordinary skill in the art would be motivated [to] modify the method of Demaray to include the teachings of Lieberman in order to obtain a highly uniform process area which is desirable for plasma processing in general by combining two frequencies with complementing energy or power distributions" (Ans. 9-10).

The Appellants argue that Lieberman in no way teaches or suggests that the 13.56 MHz frequency in Figure 8, the 40.7 MHz frequency in Figure 10, or any combinations of frequencies may be complementary or may be combined to form a net power distribution that is substantially uniform (Br. 14).

Lieberman's Figures 8 and 10 relied upon by the Examiner disclose mathematical model results which show plasma electric field directions and contours as a function of plasma sheath edge and radial edge at frequencies of 13.56 MHz and 40.7 MHz. The Examiner has not explained how that disclosure would have led one of ordinary skill in the art to apply combined RF frequencies to the same electrode such that a substantially flat power distribution is obtained as required by claims 13 and 38.

With respect to the requirement of claims 40-46 that the first electrode is positioned beneath a substrate support surface in the etch chamber the Examiner relies upon Dhindsa workpiece holder (chuck 202) to which dual frequency RF is applied (¶¶ 0024, 0029; Fig. 2), and argues that "it would

have been obvious to one of ordinary skill in the art at the time the invention
was made to select the position of first electrode below the substrate surface
in the etch chamber because Dhindsa illustrates that positioning of the
substrate would improve process uniformity across the entire wafer surface
(paragraph 0026)" (Ans. 5).

The Appellants argue that modifying Demaray's apparatus as
proposed by the Examiner would impermissibly change its principle of
operation and make it unsuitable for its intended purpose (Br. 9).

Dhindsa discloses in paragraph 0026 relied upon by the Examiner that
"[d]ue to the geometry of the upper electrode 208 and the chuck 202, the
field lines may not be uniform across the wafer surface and may vary
significantly at the edge of the wafer 204." Dhindsa obtains plasma
uniformity by use of a focus ring (218) (¶ 0026). The Examiner has not
pointed out where Dhindsa would have indicated to one of ordinary skill in
the art that the position below the wafer of the chuck (202) to which dual
frequency RF is applied provides plasma uniformity. Also, the Examiner
has not explained why one of ordinary skill in the art would have used the
location of the substrate holder (chuck 202) in Dhindsa's etching apparatus
as the location of Demaray's sputtering apparatus's sputter target's backing
plate (25) to which dual frequency RF is applied (Fig. 1a).

Conclusion of Law

The Appellants have indicated reversible error in the Examiner's
determination that the applied prior art would have rendered prima facie
obvious, to one of ordinary skill in the art, 1) a combined effect of first and
second RF signals that produces a substantially flat power distribution

(claims 13 and 38), or 2) positioning beneath a substrate support surface the electrode to which first and second RF signals are applied (claims 40-46).

DECISION/ORDER

The rejections under 35 U.S.C. § 103 of claims 1-3 and 10 over Demaray, claims 4-9, 11 and 12 over Demaray in view of Georgieva, claim 14 over Demaray in view of Georgieva and Dhindsa, and claim 36 over Dhindsa in view of Lieberman, Demaray and Georgieva are affirmed. The rejection under 35 U.S.C. § 103 of claims 13 and 33 over Demaray in view of Georgieva and Lieberman is reversed as to claim 13 and affirmed as to claim 33. The rejection under 35 U.S.C. § 103 of claims 34, 35, 37-39 and 43-46 over Dhindsa in view of Lieberman and Demaray is affirmed as to claims 34, 35, 37 and 39 and reversed as to claims 38 and 43-46. The rejection of claims 40-42 over Demaray in view of Dhindsa is reversed.

It is ordered that the Examiner's decision is affirmed-in-part.

No time period for taking any subsequent action in connection with this appeal may be extended under 37 C.F.R. § 1.136(a).

AFFIRMED-IN-PART

kmm

MOSER IP LAW GROUP / APPLIED MATERIALS, INC.
1030 BROAD STREET
2ND FLOOR
SHREWSBURY, NJ 07702